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A REVIEW ON HANDWRITTEN DIGIT RECOGNITION

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ABSTRACT

The paper's main objective is to identify handwritten writing. In the modern day, the fields of deep learning and machine learning are rapidly developing. Handwriting recognition is a practical illustration of how these technologies may be used in our everyday lives. This study examines [1] the performance of several machine learning algorithms used in handwriting recognition applications in order to evaluate their efficiency. One of the most difficult jobs for robots to do is dealing with pixel-based images since they are illegible and can come in a variety of shapes, sizes, and thicknesses.60,000 photos were utilized as training sets for pixel-based images 28 by 28. Both the practice and test handwriting images are from the MNIST database. As a result, a potential remedy for this is the Handwriting Digit Recognition Model.

Keywords: Machine Learning, Handwritten Digit Recognition, Deep Learning, Convolutional Neural Network, MNIST Dataset, Softmax Regression Algorithm, Epochs, Hidden Layers, Digit Recognition, Classification.

I. INTRODUCTION

This study assesses the effectiveness of several machine learning and deep learning handwriting recognition algorithms, as well as [1] the most effective parameters and success rates on the MNIST dataset[6]. Numeral handwriting recognition is used for a range of commercial and professional activities. They frequently carry smart phones and tablets and use the keyboard, touch screen, and smart pens to take notes in the digital realm. Banks use handwriting recognition software to read data such as check numbers, forms and other information in addition to reading and sorting incoming mail addresses. The two stages of our experiment are training and testing.

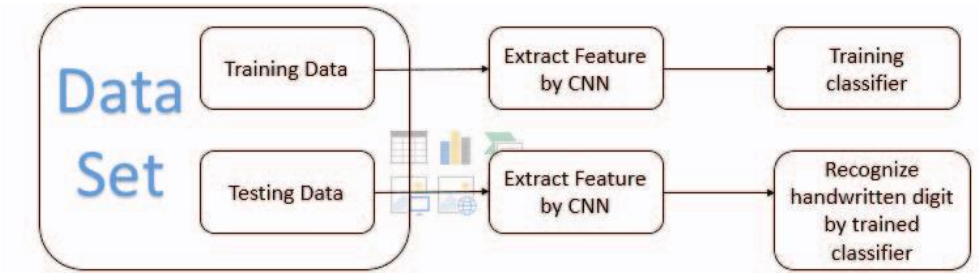

Fig. 1. Framework handwritten digit [2]

The artificial neural network used [3] in this study is a three- layer fully connected network. The "model" module of the Keras library was used to generate the "sequential" model from the neural network. [1] According to the sequential paradigm, a neural network will grow.

Artificial neural networks called convolutional neural networks were created for the purpose of convolutional training on picture data. Preprocessing is a part of HDR. If there are some limitations, such as a box for each digit, it will be much easier to locate the boundaries. It is a challenging task for machines since handwritten numbers are occasionally inaccurate for Modified National Institute training. In order to find these patterns, a handwritten digit recognition model helps.

II. RELATED WORK

Deep learning and machine learning are essential in computer technology. Here, a wide range of approaches and algorithms from diverse academics are compared and assessed for their benefits, precision, and downsides [4].

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A. HANDWRITTEN DIGIT RECOGNITION BASED ON CONVOLUTIONAL NEURAL NETWORK [2020]

[2] It has been divided in to two parts training and test. For training part, trained the convolutional neural network 20,000 times. For training part, use the numbers written by hands and the numbers from the data set to test the system. For test part, the system obtains handwritten data through the camera and constantly refreshes the predicted output in the window. Since the data set trained is the MNIST data set, all the numbers in it are in the form of white characters on a black background.

For model testing, the system employs the camera to take photos made up of images produced [2] by the test data set of MNIST then constantly processes the collected visuals and updates the output every 0.5 seconds using examples created by other authors.

[2] The loss function is an indicator in the training process. This system uses cross entropy as the loss function between the target category and the predicted category, and training always aims to reduce the loss function. TensorFlow will automatically differentiate the loss function for each variable, and then find the route of gradient descent to update the weight. TensorFlow has a large number of built in optimization algorithms. This article uses RMSProp algorithm optimizer tf.train. RMSPropOptimizer, learning rate 0.001, attenuation value 0.9, to optimize cross entropy. In each cycle, this article inputs 64 training samples, and then conducts a training session. System output a record after every 100 cycles of operation, a total of 20,000 cycles. After that this article believes that the training is over because at this time, the result of training will not be greatly improved. This is the bottleneck of the system is not insufficient training but the bottleneck of the algorithm structure. It can be seen from the training results that as the number of training steps increases, the recognition accuracy is steadily improving and the overall recognition accuracy of the final result is 97.6%.

B. HANDWRITTEN DIGIT RECOGNITION USING OPENCV AND CNN [2021]

[5] The objective of this work is to compare the accuracy of several handwritten digit classification methods by observing how they vary across hidden layer types and number of epochs used. The digit images in this collection were extracted from scanned texts; each image is Greyscale and 28 by 28 pixels in size. 60,000 photos were utilized as training sets and 10,000 as test images. An API is available to download and extract images and labels automatically when using the MNIST dataset in Keras.

One of the [6] 10 classes representing the integer values from 0 to 9 inclusively must be selected from the input image of a handwritten digit. A machine learning package called Opencv is used to read and edit photos. The image is read and several copies are then stored for use in other tasks. To ensure that the image is read correctly, it is plotted in its shape after reading. One can train a model using the fit() technique. A three-dimensional RGB image is changed into a one-dimensional, grayscale image. A three–dimensional image(w, h, and c) is a BGR image. The grayscale image is blurred using a Gaussian algorithm to reduce noise.

C. HANDWRITTEN DIGIT RECOGNITION USING PYTHON [2021]

Some basic steps in the handwritten digit recognition model are as follows. preprocessing, feature extraction , classification, training, and testing, etc. Enter several [7] digits in this step, the user draws an image of the digits on the screen. Crop the image into individual single digits as needed. Creates the various representations [7] on the screen and separates the numerals into single digits. MNIST dataset for supplying the data to follow up actions pre-processing an image to reduce it from colour to monochrome in preparation for examination;[8] in the stage where CNN is used to classify a huge quantity of data, feature extraction includes lowering the amount of resources needed to compute the value of digit using an entirely different approach. Model develop and assess a [7] model an evaluation method for machine learning algorithms is called the train test split [9]. 10,000 images are used for testing, and 60,000 images are used to prepare the database for cross-validation [10].

The intensity is represented by 28 by 28 pixels in the centre of the image, with all of the digits being greyscale and fixed in size. Since each image is 28 by 28 pixels, they all form an array that can be flattened into a vector with a dimension of 28 by 28 or 784. The filter(kernel) used by CNN to extract features from the input image is an array of weights. Each a binary number that represents the pixel's intensity makes up the vector's component [11]. It contains a menu button at the top that, when clicked, displays a drop-down list with the options "Increase Brush Size," "Decrease Brush Size," and "Brush Colour". Users can actually draw their preferred digit in the area of our software's centre panel. Shows how a user would use their mouse to design

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the shape of the number 2 on a blank space. Locally, our software can recognise digits 0 through 9.

D. HANDWRITTEN DIGIT RECOGNITION WITH MACHINE LEARNING ALGORITHMS [2022]

[12] [1] TensorFlow, Scikit Learn, Keras, and Numpy libraries were the software tools used in this work. Some numerical values are compared in the performance analyses and evaluations that are presented in the next sections of this study. [1] A performance evaluation method for machine learning classification algorithms is the [1] confusion matrix or error matrix. A performance evaluation method for machine learning classification algorithms is the confusion matrix or error matrix [13]. It provides details on how accurately the forecasts were made. It is [1] a table with 4 combinations of forecasted values and actual values.

Metrics can be used for [1] precision, recall, support, accuracy, specificity, and F1 score with the use of this matrix. This is how the image gets transformed [1] into a binary image, specifically a black and white image. The main goal is to draw attention to the picture and make it clear. Every distinctive element in the images may be called an attribute. Tensorflow, Keras, Scikit-Learn, and Numpy are just a few of the essential libraries included in [1] the project. The MNIST dataset from the Tensorflow-Keras library is included in the project. After being tagged, the data was [1] split into training and test sets. The data went through preprocessing procedures. The data was then normalised and characteristics were extracted after the preparation procedures. There are defined [1] algorithms to be used with libraries. The parameters to be used during training for each technique were chosen based on the best approach for the dataset. The ”Fit” function was used to train the dataset, and model training was finished. [1] While Tensorflow and Keras libraries were used for neural networks, KNN, SVM, Decision Tree, and Naive Bayes algorithms all made extensive use of the Scikit Learn library during learning. On a section of the dataset set aside for testing, the model was assessed using the ”Predict” function. Finally, [1] using the ”classification report” and ”confusion matrix” functions of the ”metrics” module of the Scikit Learn library, a report containing [1] the classification report and confusion matrix was created and shown to evaluate [1] the performance of the trained and tested model.

The classification report displays [1] the precision, recall, f1 score, support, and accuracy scores obtained from the confusion matrix findings in tabular format. All of the data from the data set, totaling 70000 bits, was used, with 60000 bits put aside for training and 10,000 bits set aside [1] for testing, and the ratios of these components were maintained throughout all models.

III. COMPARATIVE STUDY

Although [2]the handwritten digit recognition method in this article functioned well, this is insufficient. The system displays extremely high identification accuracy for these images with black backgrounds and white lettering. But during [2] the process, it was found that because the system only recognises white characters on a black background, if the camera is too far away from the object, both the object and the white background behind it [2] in the object extraction area will interfere with the recognition significantly. Chao zhang et al focuses on [2] convolutional neural network. Two algorithms convolutional neural network, softmax regression algorithms are using here first one is multiclassification issues and other one is so the main objectives is to reduce [2] scale of the model, learning complexity, and reduce the number of network conncetions.

In general, [2] the system has a high accuracy rate for handwritten numbers [2] as long as the input requirements are met (i.e., there is only object data in the object extraction area). The output window continuously updates the extraordinarily high accuracy rate of the recognition result. The training results show that the identification accuracy improves continuously as the number of training steps grows, [2] and the overall recognition accuracy of the end result is 97.6%.

The first paper uses the algorithm softmax regression algorithm, but the second paper CNN [14] are trained using real time data, which simplifies the model by lowering the number of variables and providing pertinent accuracy. Opencv and CNN in this part, we evaluate the performance of the MNIST database using five different [15] classification algorithms: K-Nearest Neighbours, Logistic Regression, Convolutional Neural Network, Random Forest Classifier [16], and Support Vector Machine. [14] Because each module is created to address a single subproblem, training is less complicated. Given CNN’s great accuracy, the model is trained using this data. [14] Convolutional neural networks are trained using real time data, which simplifies the model by cutting down on the number of variables while yet providing adequate accuracy. In the [2]first paper for the [2] model

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test, the system employs the camera to record images made up of images created [2] by the test data set of MNIST and samples authored by other authors. The captured graphics are then continually processed and every 0.5 seconds, the output is refreshed but in the second paper import from Keras the MNIST dataset for handwritten digits. [14] It has 10,000 test pictures and 60,000 training images, both of which are grayscale 28 by 28 pixel images of handwritten single digits from 0 to 9. An API is available to download and extract pictures and labels automatically when using the MNIST dataset with Keras.The second paper achieves high accuracy close to that of the first paper.

Libraries such as Keras, Mathplotlib, CV2 and tenserflow can be will get higher accuracies[17] . The accuracy of CNN is 99.63% in a comparison of various machine learning methods, including Random Forest Classifier, Convolutional Neural Network, Linear Regression, K-Nearest Neighbours, and Support Vector Machine. We will get high accuracy while using CNN than other algorithms that is [18] K-Nearest Neighbors, Logistic Regression, Random Forest Classifier and Support Vector Machine.

In the third work intensity is represented by 28 by 28 pixels in the centre of the image, with all of the digits being grayscale and fixed in size. Since each image is 28 by 28 pixels, they all form an array that can be flattened into a vector with a dimension of 28 by 28 or 784. This section describes the many advancements and acknowledgements, including general algorithms, techniques, datasets used, and the creation and testing of models. The actuation capacities of the sigmoid, softmax, relu and tanh are examined during the execution of the experiment. Adam optimizer, 0.1 dropout, and sigmoid activation function are used. The precision of testing and training is unaffected by increasing batch size. Demonstrates the effects of the [19] Adam optimizer, the sigmoid activation function, the 100 Batch size, and the [19] 60 epochs with varying learning rates. On the MNIST dataset, accuracy is often more than 98%-99%. Training accuracy in the learning rate experiment is 0.01 is 98.99%, and testing accuracy is 98.84%. When learning rate is very less that is 0.02 indicate a testing accuracy or 96.41% and so it shows a training accuracy of 98.06%. When it is high that means 0.01 it has got 98.99%, 98.84% of training accuracy and testing accuracy respectively. When learning rate is increasing corresponding percent of training accuracy and testing accuracy decreases. In the second study aims to investigate the effects of different handwriting algorithms. In our study we used OpenCV, A Python machine learning toolkit to train the CNN [20] algorithm on the Modified National Institute of Standards and Technology (MNIST) dataset and in the third study implementation of a CNN based handwritten digit identification model that uses an [21] image of a digit to identify the digit contained in the picture is the aim of our project. The MNIST data collection is used to assess the performance. The network was evaluated on 10,000 samples of numeric data after training on 60,000 samples.

Preprocessing the raw data can increase the handwritten numeral recognition algorithm's accuracy. Image noise and unreadable handwriting are the main problems found after a quick analysis of the raw image data. Therefore, it is thought that preprocessing the raw data is required before training them. To move past the preprocessing stage, a number of image processing techniques are used. As a result of our software in practice. For our own programme, we have built a straightforward and incredibly user-friendly UI. Both first and second paper acheived less accuracy rate in the third study acheived 99.87%.

In contrast to the first, second, and third publications, which machine learning method is the most successful in handwriting recognition applications is examined in this study. The fourth study "PyQt5" package. Designed [1] for the graphical user interface of the Python programming language, was used [1] in this project to construct an interface application for the end user. [1] The parameter values of the trained algorithms employed in the training are listed and displayed to the user's information in the "Modeller" page of the [1] application.

[1] An accuracy rate of more than 80% was attained in all models, according to the experiment done using the MNIST data set in handwriting recognition techniques. With the CNN- Adam model, the maximum accuracy rate was attained, which is 99.45%.

The ANN-Adam model, which came in second to convolutional neural network models, had the greatest accuracy rate at 98.66%. Additionally, the accuracy of the K-NN model in the same data set with 3 neighbours was 97.05%, while the accuracy of the SVM-poly model was 97.71%. These models have also seen significant success.

IV. CONCLUSION

[2] In large-scale data statistics and the financial industry, such as industrial yearly inspection, population census, tax statements and checks, etc., handwritten digit recognition is crucial. We have described a thorough approach for quickly and accurately recognising [2] handwritten digits in this work. For handwritten digit recognition written by distinct people, our approach offers very good recognition accuracy. Such as bright and dim lighting, as well as cloudy and sunny days. In the test phase, we had a pleased recognition rate. When compared to established traditional methods like the Histogram of Oriented Gradient (HOG), the benefits are clear. In the second paper by broadening the project's focus to include many writing styles, it can be advanced. By using large datasets, we can improve accuracy. Using a variety of appropriate algorithms weaking for hyper parameters increase the number of epochs used when compiling the model. Pennan rajput et al focuses on [22] neural network (NN) [22] methods are the main topic. [19] Convolutional neural network (CNN) is one of the three well-known NN techniques, along with [23] deep neural network (DNN), deep belief network (DBN), and deep neural network (DBN). CNN is distinguished from other NN by its focus on being able to recognise patterns.

The fourth paper following methods were chosen: [1] ANN, CNN, K-NN, Naive Bayes algorithm, SVM, and decision trees. Each of these algorithms was thoroughly reviewed, and tests were run on the MNIST dataset for each of them. When [23] the models were compared in terms of accuracy, ANN and CNN models performed the best. The ANN-Adam model had [1] a success rate of 98.66%, while the CNN- Adam model had a success rate of 99.45%. Handwritten digit recognition is crucial to [2] daily production and existence, and this research will help people who work with numbers become more productive and encourage a more intelligent way of living.

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